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for

COVERING SYSTEMS AND VENTING METHODS

by

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This application is a continuation-in-part of the co-pending patent application entitled "COVERING SYSTEMS AND VENTING METHODS," which was filed in the names of the presently-named inventors on October 5, 2001.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to covers for liquid-retaining structures, covering systems that utilize such covers, and venting methods.

2. Description of Related Art

Covers for liquid-retaining structures, such as lagoons, ponds, basins, and tanks, have existed for many years. Such liquid-retaining structures have been used in a variety of environments, including holding fresh water or wastewater for industrial, municipal, and/or agricultural operations, and the like. Covers have been used to address issues such as odors, algae growth, heat loss, and gas production and collection associated with the retained liquids. Such gases include, for example, methane and hydrogen sulfide. Examples of such covers include those found in U.S. Patent Nos. 3,991,900, 4,438,863, 5,265,976, 6,136,194, 4,294,589, 5,400,549, and 5,562,759.

Despite their utility in certain areas, current covers do not offer a simple, inexpensive way to address issues such as odor control or algae control while providing the ability to release gas at the same time. While certain of the covers identified above, such as those depicted in U.S. Patent Nos. 5,400,549 and 5,562,759 (the disclosures of both of which are incorporated herein by reference) provide for a modular construction, the disclosed modules include large, insulative enclosures that span nearly the entire space of the module. As a result, the modules are expensive. Additionally, while gaps exist between the connected modules through which gas may escape, the covers lack a controlled gas-release system that does not depend upon modules being connected to each other. Of the non-modular covers that exist, some employ expensive, complicated systems of gas control that include pipes for directing the gas and pumps to stimulate the movement of the gas.

SUMMARY OF THE INVENTION

The present covers, covering systems, and methods address the shortcomings of prior covers by providing a way to address issues such as odors, algae growth, and heat loss associated with the retaining various liquids, while permitting for the controlled release of gases that are produced. This is achieved through covers and covering systems that may be modular and, as a result, well-suited to covering any liquid-retaining structure, from lagoons to tanks. The modules may take the form of the present membranes. The modules may also take the form of the present membranes that are coupled to one or more of the present flotation members. The modules may be connected together by, for example, permanent connections (e.g., welds) or connections that are temporary (such as fasteners). The present covers and covering systems may be provided with various anchoring structures that allow the cover or covering system to be affixed to various structures such as pond banks or tank sides. By doing so, the likelihood that wind can get beneath the cover or covering systems and impair its effectiveness can be reduced or eliminated. Furthermore, the present covers and covering systems may be formed in part from membrane(s) that float by virtue of the material from which they are made and/or by virtue of the present flotation members.

In one embodiment, the present invention is a covering system that includes a first membrane and a first flotation member coupled to the first membrane. The first flotation member includes a first float and a first float compartment membrane, and the first float compartment membrane is coupled to the first membrane. The covering system also includes a first plurality of gas-relief passageways positioned either within the first float compartment membrane, or within the first membrane and adjacent to the first flotation member. At least one of the gas-relief passageways within the first plurality is structured so that gas flows unobstructed through it when the system is used.

In another embodiment of this covering system, the first float is sealed in the first float compartment membrane. In other embodiments of this covering system, the first float compartment membrane is coupled to the first membrane with at least either a flotation member tie or a flotation member strap.In another embodiment of this covering system, the first float compartment membrane is coupled to either an upper surface or a

lower surface of the first membrane, and the first float is positioned between the first membrane and the first float compartment membrane. In another embodiment of this covering system, the first flotation member is coupled to the first membrane so as to elevate the first plurality of gas-relief passageways above at least a portion of the first membrane when the system is used.

In another embodiment of this covering system, the covering system includes a second membrane and a second flotation member coupled to the second membrane. The second flotation member includes a second float and a second float compartment membrane, and the second float compartment membrane is coupled to the second membrane. The covering system also includes a flotation member link coupling the first flotation member to the second flotation member, and a second plurality of gas-relief passageways positioned either within the second float compartment membrane, or within the second membrane and adjacent to the second flotation member. At least one of the gas-relief passageways within the second plurality is structured so that gas flows unobstructed through it when this embodiment of the covering system is used.

In still another embodiment of this covering system, the covering system includes a second flotation member coupled to the first membrane. The second flotation member includes a second float and a second float compartment membrane, and the second float compartment membrane is coupled to the first membrane. The second flotation member is spaced apart from the first flotation member. This embodiment of the covering system also includes a first elongated weight positioned on an upper surface of the first membrane and between the first and second flotation members.

In yet another embodiment of this covering system, the covering system includes a second elongated weight positioned on an upper surface of the first membrane at an angle to either the first flotation member, the second flotation member, or the first elongated weight.

In yet another embodiment of this covering system, the covering system includes an anchor system coupled to an edge of the first membrane. In one embodiment, the anchor system includes a weighted member extending along and coupled to at least a portion of the edge of the first membrane. In another embodiment of this covering

system, the anchor system further includes a connector coupled to the edge of the first membrane. The connector may include a sleeve.

In still another embodiment of this covering system, the covering system further includes a service opening positioned within the first membrane. The service opening may be defined by a service opening edge and may be spaced apart from the first flotation member and the first plurality of openings. In this embodiment, the covering system further includes a second flotation member coupled to the first membrane so as to elevate the service opening edge above a body containing some liquid when the system is used. In this embodiment, the covering system also includes a service opening membrane coupled to the service opening edge. A service opening weight may be coupled to the service opening membrane and spaced apart from the service opening edge.

In another embodiment, the present invention is a covering system that includes a first membrane having a width and a first float coupled to the first membrane, the first float having a width that is not more than twenty-five percent of the width of the first membrane. In this embodiment, the covering system also includes a second membrane that is coupled to the first membrane so as to define gas-relief openings between the first and second membranes.

In another embodiment of this covering system, the first float is sealed in a first float compartment membrane, and the first float compartment membrane is coupled to the first membrane.

In still another embodiment of this covering system, the first float is coupled to the first membrane with a first float compartment membrane, and the first float compartment membrane is coupled to either an upper surface or a lower surface of the first membrane. In this embodiment, the first float is positioned between the first membrane and the first float compartment membrane.

In yet another embodiment of this covering system, the covering system also includes a second float that is coupled to the first membrane; the second float is spaced apart from the first float; and a first elongated weight is positioned on an upper surface of the first membrane and between the first and second floats. In yet another embodiment of

this covering system, the covering system further includes a second elongated weight positioned on an upper surface of the first membrane at an angle to either the first float, the second float, or the first elongated weight.

In still another embodiment of this covering system, the covering system includes an anchor system coupled to an edge of the first membrane. In this embodiment, the anchor system includes a weighted member extending along and coupled to at least a portion of the edge of the first membrane. In another embodiment, the anchor system further includes a connector coupled to the edge of the first membrane. In another embodiment, the connector includes a sleeve.

In yet another embodiment of this covering system, the covering system has a service opening positioned within the first membrane, the service opening is defined by a service opening edge, and the service opening is spaced apart from the first float and the gas-escape openings. In this embodiment, the covering system includes a second flotation member coupled to the first membrane so as to elevate the service opening edge above a body containing some liquid when the system is used, and a service opening membrane coupled to the service opening edge. In another embodiment, this covering system further includes a service opening weight coupled to the service opening membrane and spaced apart from the service opening edge.

In another embodiment, the present invention is a floating cover that includes a first membrane and a service opening positioned within the first membrane. The service opening is defined by a service opening edge. In this embodiment, the floating cover also includes a flotation member coupled to the first membrane so as to elevate the service opening edge above a body containing some liquid when the system is used. In this embodiment, the floating cover also includes a service opening membrane coupled to the service opening edge. In another embodiment, the floating cover includes a service opening weight coupled to the service opening membrane and spaced apart from the service opening edge.

In another embodiment, the present invention is a venting method that includes coupling a first membrane to a first flotation member. The first flotation member includes a first float and a first float compartment membrane. The coupling includes

coupling the first float compartment membrane to the first membrane. In this embodiment, the venting method also includes forming gas-relief passageways either within the first float compartment membrane, or within the first membrane and adjacent to the first flotation member. In this embodiment, the venting method includes elevating at least a portion of the first membrane so as to cause the first membrane to float when placed over a body containing some liquid, and so that gas from the body is unobstructedly vented to atmosphere through at least one of the gas-relief passageways. In another embodiment, the coupling includes welding the first float compartment membrane to the first membrane.

In another embodiment, the present invention is a venting method that includes coupling a first membrane having a width to a first float having a width that is not more than twenty-five percent of the width of the first membrane; coupling a second membrane to the first membrane so as to define gas-relief openings between the first and second membranes; placing the coupled first and second membranes over a body containing some liquid; and elevating the gas-relief openings over the body so that gas from the body is unobstructedly vented to atmosphere through at least one of the gas-relief openings. In another embodiment, the coupling the second membrane to the first membrane includes welding the second membrane to the first membrane. As used in this document, including the claims, welding one membrane to another membrane (or welding one thing to another) includes creating a continuous, elongated weld between the two, or creating one or more shorter welds between the two.

In another embodiment, the present invention is a method of venting gas from a body containing some liquid. The method includes placing a covering system over the body. The covering system includes a first membrane having an outer edge and a width and a first flotation member coupled to the first membrane. The first flotation member includes a first float and a first float compartment membrane. The first float has a width that is not more than twenty-five percent of the width of the first membrane and a first float compartment membrane, and the first float compartment membrane is coupled to the first membrane. The method also includes elevating portions of the first membrane above the body; and positioning the covering system to allow gas from the body to vent to atmosphere around the outer edge of the first membrane.

BRIEF DESCRIPTION OF THE DRAWINGS

The following drawings form part of the present specification and are included to further demonstrate certain aspects of the present covers and covering systems. The present covers, covering systems, and methods may be better understood by reference to one or more of these drawings in combination with the description of illustrative embodiments presented herein.

FIG. 1 is a perspective view of one embodiment of the present covers and covering systems that includes a flotation member coupled to a membrane with fasteners. Also shown are a plurality of gas-relief passageways.

FIG. 2 is a perspective view of another embodiment of the present covers and covering systems that includes three membranes and two flotation members.

FIG. 3 is a side view (showing certain aspects in cross-section) of one embodiment of an anchor system coupled to one embodiment of the present covers and covering systems.

FIGS. 4A-G illustrate various embodiments of the manner in which the present flotation members can be coupled to the present membranes through the use of welding.

FIG. 5A-G illustrate various embodiments of the manner in which the present flotation members can be coupled to the present membranes through the use of fasteners.

FIG. 6 depicts an enlarged, close-up view (showing certain aspects in cross-section) of a portion of one embodiment of the present covers and covering systems that illustrates that gas that collects in a gas pocket may pass through one of the present gas-relief passageways.

FIG. 7 depicts a top view of one embodiment of the present covers and covering systems that illustrates multiple membranes and multiple flotation members coupled together to cover a rectangular area.

FIG. 8A depicts a perspective view of a portion of one embodiment of the present covers and covering systems, which embodiment includes a service opening positioned within one of the present membranes and a service opening membrane coupled to the

service opening edge that defines the service opening. The service opening edge is shown as being elevated via one of the present flotation members that takes the form of four floats.

FIG. 8B depicts the portion of the embodiment shown in **FIG. 8A**, except the embodiment of the present flotation member takes the form of a single float.

FIG. 9A depicts a perspective view of a portion of one embodiment of the present covers and covering systems, which embodiment includes a service opening positioned within one of the present membranes and a service opening membrane coupled to the service opening edge that defines the service opening. The service opening edge is shown as being elevated via one of the present flotation members that takes the form of four floats, and multiple service opening weights coupled to the service opening membrane.

FIG. 9B depicts the portion of the embodiment shown in **FIG. 9A**, except the embodiment of the present flotation member takes the form of a single float.

FIG. 10 depicts a view similar to the one shown in **FIG. 6**, and illustrates the width **WF** of one of the present floats and the width **WM** of one of the present membranes.

FIG. 11 depicts a perspective view of one embodiment of the present covers and covering systems that includes two membranes coupled to each other so as to form multiple gas-relief openings between them.

FIGS. 12A-C illustrate various embodiments, in addition to those depicted in **FIGS. 4A-G** and **FIGS. 5A-G** of the manner in which the present flotation members can be coupled to the present membranes.

FIG. 13 depicts a perspective view of one of the present flotation members coupled to one of the present membranes with multiple spot welds.

FIG. 14 depicts a perspective view of two flotation members coupled together with one of the present flotation member ties.

DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

As a preliminary matter, it should be noted that in this document (including the claims), the terms "comprise" (and any form thereof, such as "comprises" and "comprising"), "have" (and any form thereof, such as "has" and "having"), and "include" (and any form thereof, such as "includes" and "including") are open-ended transitional terms. Thus, a thing (such as a covering system, a cover, or a venting method) that "comprises," "has," or "includes" one or more elements possesses those one or more elements, but is not limited to only possessing those one or more elements. For example, a covering system "comprising" a first membrane, a first flotation member, and a first plurality of gas-relief passageways is a system that has, but is not limited to only having, these items. In other words, the covering system possesses a first membrane, a first flotation member, and a first plurality of gas-relief passageways, but is not excluded from possessing additional elements or features that are not listed.

FIG. 1 illustrates one embodiment of the present covers and covering systems. It shows membrane **10** (which may be characterized as a first membrane, a second membrane, etc., depending upon the context, as is true of all of the present membranes), and flotation member **20** coupled thereto. Flotation member **20** (which may be characterized as a first flotation member, a second flotation member, etc., depending upon the context, as is true of all of the present flotation members) includes float **22** (which may be characterized as a first float, a second float, etc., depending upon the context, as is true of all of the present floats), and float compartment membrane **24** (which may be characterized as a first float compartment membrane, a second float compartment membrane, etc., depending upon the context, as is true of all of the present float compartment membranes). While flotation member **20** is coupled to membrane **10**, this arrangement may also be described by the fact that float compartment membrane **24** is coupled to membrane **10**. As shown in **FIG. 1**, this coupling may take place through the use of fasteners **12**. Fasteners **12** may be any suitable mechanical connector, such as nuts and bolts; rivets; latches; screws; plungers; clamps; various combinations of pins, collars, and nuts; and the like. Such mechanical connectors may be made from any

suitable material, or combination of materials, including plastic and metal, such as stainless steel.

As shown in **FIG. 1**, the embodiment of the cover or covering system shown is positioned over a liquid-retaining structures, such as a pond, defined by bed **14** and filled with some liquid **16**. The surface of the liquid is denoted as **18**. One embodiment of an anchor system **70** is shown in **FIG. 1**. This embodiment of anchor system **70** includes weighted member **72** (which may be characterized as a first weighted member, a second weighted member, etc., depending upon the context, as is true of all of the present weighted members), which, in turn, includes weighted member membrane **74** (shown in the form of a tube and which may be characterized as a first weighted member membrane, a second weighted member membrane, etc., depending upon the context, as is true of all of the present weighted member membranes) and internal component **73** (which may be characterized as a first internal component, a second internal component, etc., depending upon the context, as is true of all of the present internal components). Anchor system **70** is coupled to edge **34** (which may be characterized as a first edge, a second edge, an inside edge, an outside edge, etc., depending on the context and particular application, as is true of all of the present membrane edges) of membrane **10** and, more specifically, weighted member membrane **74** is coupled to edge **34** of membrane **10**. The coupling may be achieved using any suitable means, including one or more welds, or any of the fasteners mentioned above. The type of welds that may be used include those created through the use of hot air, a hot wedge, a hot liquid such as a plastic or plastic-like substance, through extrusion, through the use of a chemical (such as a solvent), through the use of radio frequency or ultra sonic means, or the like. All of the couplings described herein can be achieved using any of the permanent or non-permanent mechanisms disclosed above.

Also shown in **FIG. 1** is a plurality of gas-relief passageways that include gas-relief passageways **26**. The number of the present gas-relief passageways that may be included in a plurality of gas-relief passageways varies in number, and will depend upon the application. For example, a plurality of the present gas-relief passageways may include 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49,

50 or more, depending upon the application. The present gas-relief passageways may be formed within the present membranes or float compartment membranes using, for example, any suitable drilling techniques (such as with a drill), cutting tools (e.g., a knife), punches, scissors, presses, and the like. In addition, the edges of the gas-relief passageways may be reinforced if suited to the application using, for example, grommets, reinforcing patches or welding-like material that may be placed around all or part of the passageway, and the like.

As shown in **FIG. 1**, passageways **26** may be positioned within membrane **10** and adjacent to flotation member **20**. Alternatively, these gas-relief passageways can be positioned within both flow compartment membrane **24** and membrane **10**. The present gas-relief passageways can be structured so that gas rising above liquid **16** can flow unobstructed through the passageways when the embodiment shown in **FIG. 1** is used. As used in this document, including the claims, a gas-relief passageway that is structured so that gas flows unobstructed through it when the cover or covering system of which it is a part is used means that the passageway is designed and created to be used without a fastener or other obstructing device within it. In addition to flowing through the gas-relief passageways, gas may also flow through the openings through which fasteners 12 are placed. This flow would not be unobstructed, however.

FIG. 2 is a perspective view of another embodiment of one of the present covers and covering systems. Like the embodiment shown in **FIG. 1**, the embodiment shown in **FIG. 2** includes membrane **10** coupled to flotation member **20**. In this embodiment, however, flotation member **20** includes not only float **22** and float compartment membrane **24**, but also float compartment membrane **25**. As shown, float compartment membrane **24** is coupled to upper surface **13** of membrane **10** rather than lower surface **11**, and float compartment membrane **25** is coupled to float compartment membrane **24**. Fasteners **12** are used to couple membrane **10**, float compartment membrane **24**, and float compartment membrane **25** as just described, and welds (not shown for simplicity) are used to couple membrane **40**, float compartment membrane **24**, and float compartment membrane **25**. **FIG. 2** also illustrates gas-relief passageways **26** positioned within float compartment membranes **24** and **25**, and within membrane **10** on the opposite side of flotation member **20** from fasteners **12**.

As shown in **FIG. 2**, spaced apart from flotation member **20** is flotation member **50**, which includes float **52** and float compartment membranes **54** and **55**. As shown, flotation member **50** is coupled to both membrane **10** and to membrane **60**. More specifically, float compartment membrane **54** is coupled to upper surfaces **13** and **63** of membranes **10** and **60**, respectively. Float compartment membrane **55** is coupled to float compartment membrane **54**. Fasteners **12** and gas-relief passageways **26** are positioned within flotation member **50** in the same fashion as their position within flotation member **20**.

FIG. 2 also shows anchor system **70**, which, in one embodiment, includes weighted members **72**. As shown in **FIG. 2**, a given weighted member can include internal component **73** and weighted member membrane **74**. Internal component **73** may consist of sand, dirt, concrete, a slurry of any of these, or any other suitable material. One or more weighted members may make up a give anchor system, depending on the requirements of the application.

As shown in **FIG. 2**, anchor system **70** is coupled to edges **15**, **45** and **65** of membranes **10**, **40**, and **60**, respectively. More specifically, weighted members **72** are coupled to edges **15**, **45** and **65** of membranes **10**, **40**, and **60**, respectively. Even more specifically, weighted member membranes **74** are coupled to edges **15**, **45** and **65** of membranes **10**, **40**, and **60**, respectively. As used in this document, including the claims, a thing (such as an anchor system, a weighted member, a weighted member membrane, or the like) that is coupled to an edge of a membrane may be attached to the membrane either at the edge of the membrane or near the edge of the membrane.

Although shown in **FIG. 2** as being coupled to the edges of all three membranes, those of skill in the art having the benefit of this disclosure will understand that anchor system **70** may be coupled to only one of membranes **10**, **40** and **60** or to any combination of the membranes that is fewer than all of them. Thus, an anchor system consistent with this disclosure may be adapted to suit the particular application. Similarly, although shown in **FIG. 2** as including seven weighted members **72**, those of skill in the art having the benefit of this disclosure will understand that as few as one weighted member **72** may be a part of an anchoring system coupled to one of the present

covers or covering systems, and alternatively, as many weighted members as are necessary for the application may be used.

In another embodiment, which is also shown in **FIG. 2**, anchor system **70** may include one or more connectors **76** (which, individually, may be characterized as a first connector, a second connector, etc., depending upon the context, as is true of all of the present connectors), which, as shown in **FIG. 2**, may take the form of sleeves (which may be characterized as a first sleeve, a second sleeve, etc., depending upon the context, as is true of all of the present sleeves). Connectors **76** (which are only partially visible in **FIG. 2**) are shown in **FIG. 2** as being coupled to edges **15**, **45**, and **65**. Connectors **76** may also take the form pipes, such as those made of plastic or metal. Although five connectors **76** are shown in **FIG. 2**, those of skill in the art having the benefit of this disclosure will understand that as few as one connector or as many as are needed for a particular application may be coupled to one or more of edges **15**, **45**, and **65**. In one embodiment, anchoring cables **78** (which, individually, may be characterized as a first anchoring cable, a second anchoring cable, etc., depending upon the context, as is true of all of the present anchoring cables) may be placed through connectors **76** and used to secure connectors **76**, and thus the embodiment of the present covers and covering systems shown in **FIG. 2**, to bank **60**. More specifically, one or more anchoring holes **80** (which, individually, may be characterized as a first anchoring hole, a second anchoring hole, etc., depending upon the context, as is true of all of the present anchoring holes) may be created in bank **60**, into which one or more anchoring stakes **82** (which, individually, may be characterized as a first anchoring stake, a second anchoring stake, etc., depending upon the context, as is true of all of the present anchoring stakes) may be placed and anchored in cement. As shown in **FIG. 2**, an anchoring cable **78** may be coupled to an anchoring stake **82** in order to secure the embodiment of the present covers and covering systems.

As an alternative to anchor system **70**, and as is known in the art, an anchor trench may be used as a means of securing one of the present covers or covering systems to a bank. That is, a trench that may be any suitable distance from the liquid surface may be dug, the edge or edges of the membrane or membranes being used may be placed in the trench, and the trench may be backfilled with earth, concrete, or the like. The trench may

be any width and depth suited to the application, such as being two feet wide by two feet deep. The trench may also extend along the bank any suitable distance. It will be understood that alternatively, an embodiment of the present anchor systems **70** that includes weighted members **72**, but not connectors **76**, may be used in combination with an anchor trench to achieve suitable anchoring of the cover or covering system to a bank or other earthen structure.

As another alternative to anchor system **70**, batten bars may be used to anchor one of the present covers or covering systems to a bank or other structure. The use of batten bars, as those of skill in the art will understand, would involve effectively pinching one or more of the present membranes between one or more batten bars, and an underlying substrate, such as concrete.

Elongated weights may also be used in conjunction with the present covers and covering systems to control rainwater drainage and collection. For example, one or more elongated weights **90** (which, individually, may be characterized as a first elongated weight, a second elongated weight, etc., depending upon the context, as is true of all of the present elongated weights) may form part of the embodiment of the present covers and covering systems shown in **FIG. 2**. Elongated weights **90** are positioned on upper surface **13** of membrane **10**, and between flotation members **20** and **50**. These elongated weights, which, for example, may take the form of tubes filled with sand, earth, etc., or any other suitable mass (even pipes made of suitably heavy plastic, metal, or concrete), are useful in creating channels (such as channel **92** shown in **FIG. 2**) within which rainwater or any other liquid resting on upper surface **13** of membrane **10** may flow. Pumps or other mechanisms may be used to siphon off water collected as the result of using such channels.

In use, the bottoms of flotation members **20** and **50** depicted in **FIG. 2** will rest beneath liquid surface **18**. The same thing will happen to the portion of membrane **10** beneath elongated weights **90**. Because the portion of membrane **10** located beneath elongated weights **90** will be pushed beneath liquid surface **18** in use, any gas that collects beneath the embodiment of the present covers and covering systems shown in **FIG. 2** will migrate toward flotation members **20** and **50**. Furthermore, because the

bottoms of flotation members **20** and **50** will be positioned beneath liquid surface **18**, that gas will have no place to go but up through either gas-relief passageways **26**, or up through the openings through which fasteners **26** are placed.

Membranes, such as membranes **10**, **40**, and **60** shown in **FIG. 2**, may be coupled together in any number and fashion best-suited to a particular application. Accordingly, the membranes may take on any suitable shape, including rectangular, triangular, round, hemispherical, etc., depending on the shape of the liquid-retaining structure being covered. The disclosed membranes, as well as the disclosed float compartment membranes, may be formed from any suitable material, including Hypolon, polyvinyl chloride (PVC), polypropylene, XR-5, high density polyethylene, plastic, geomembrane, geotextile. In addition, if properly treated, certain types of cloth, canvas, or paper also may be used. These same materials may be used for the disclosed weighted member membranes and connectors. The disclosed floats may be formed from any suitable material, including foam, insulation, paper, plastic, an air- or gas-filled bladder (such as an inflated tube or bubble wrap), expanded or extruded polystyrene foam, polypropylene foam, polyethylene foam, and the like. These materials may be formed to size, or cut to size using, for example, any of the tools discussed above for use in forming gas-relief passageways **26**.

FIG. 3 is an elevational view of showing anchor system **70** coupled to edge **45** of membrane **40** (which is shown in **FIG. 2**). Specifically, **FIG. 3** illustrates weighted member **72**, and more specifically weighted member membrane **74**, coupled to edge **45** of membrane **40**. This coupling may occur through the use of any of the mechanisms described herein, including welds, fasteners, and the like. **FIG. 3** also illustrates connector **70** being coupled to edge **45** of membrane. This coupling may also occur through the use of any of the mechanisms described herein, including welds, fasteners, and the like. **FIG. 3** shows hole **80**, or earth anchors(earth screws) which may be dug to any suitable level (e.g., from one to ten feet), into which anchoring stake **82** has placed and anchored in concrete **85** (or any other suitable material).

FIGS. 4A-G, **5A-G**, and **12A-C** illustrate various embodiments of the manner in which the present flotation members can be coupled to the present membranes. More

specifically, these figures illustrate various embodiments of how the present membranes and the present float compartment membranes may be coupled together using different attachment mechanisms. Although welds, fasteners, flotation member straps, and flotation member ties are the attachment mechanisms disclosed in these figures, other attachment mechanisms, such as those disclosed herein, may be used if appropriate for a given application.

FIGS. 4A and **5A** illustrate flotation member **20** coupled to membrane **10**. Flotation member **20** includes float **22** and float compartment membrane **24**. As shown in both figures, float **22** is positioned between float compartment membrane **24** and membrane **10**. In both figures, float compartment membrane **24** is coupled to upper surface **13** of membrane **10**. **FIG. 4A** shows that the coupling may be achieved through the use of welds **17**, and **FIG. 5A** shows that the coupling may be achieved through the use of fasteners **12**. In both figures, membrane **10** and float compartment membrane **24** form float compartment **27**. This float compartment can be sealed using any suitable mean, including, for example, welds **17** as shown in **FIG. 4A**. As used in this document, including the claims, an enclosure that is sealed is one that is airtight and/or watertight. Thus, a float that is sealed within a membrane of some sort, or within an enclosure (such as a float compartment) would be free from water or air penetrating the sealed environment. Those of skill in the art will understand, however, that even sealed enclosures as described herein may, over the course of normal wear and tear, be penetrated by air or water, as it would be virtually impossible to ensure otherwise.

FIGS. 4B and **5B** illustrate flotation member **20** coupled to membranes **10** and **40**. In both figures, flotation member **20** includes float **22** and float compartment membranes **24** and **25**. As shown in both figures, float **22** is positioned between float compartment membranes **24** and **25**. In both figures, float compartment membrane **24** is coupled to upper surface **13** of membrane **10** and to upper surface **43** of membrane **40**, which is shown as also having lower surface **41**. In both figures, float compartment membrane **25** is coupled to float compartment membrane **24**. **FIG. 4B** shows that the above-described coupling may be achieved through the use of welds **17**, and **FIG. 5B** shows that the above-described coupling may be achieved through the use of fasteners **12**. In both figures, float compartment membranes **24** and **25** form float compartment **27**.

This float compartment can be sealed using any suitable mean, including, for example, welds **17** as shown in **FIG. 4B**.

FIGS. 4C and **5C** illustrate flotation member **20** coupled to membrane **10**. Flotation member **20** includes float **22** and float compartment membrane **24**. As shown in both figures, float **22** is positioned between float compartment membrane **24** and membrane **10**. In both figures, float compartment membrane **24** is coupled to lower surfaces **11** (in two locations) and **41** of membranes **10** and **40**, respectively. **FIG. 4C** shows that the coupling may be achieved through the use of welds **17**, and **FIG. 5C** shows that the coupling may be achieved through the use of fasteners **12**. In both figures, membrane **10** and float compartment membrane **24** form float compartment **27**. This float compartment can be sealed using any suitable mean, including, for example, welds **17** as shown in **FIG. 4C**.

FIGS. 4D and **5D** illustrate flotation member **20** coupled to membrane **10**. Flotation member **20** includes float **22** and float compartment membrane **24**. As shown in both figures, float **22** is positioned between float compartment membrane **24** and membrane **10**. In both figures, float compartment membrane **24** is coupled to lower surface **11** of membrane **10**. **FIG. 4D** shows that the coupling may be achieved through the use of welds **17**, and **FIG. 5D** shows that the coupling may be achieved through the use of fasteners **12**. In both figures, membrane **10** and float compartment membrane **24** form float compartment **27**. This float compartment can be sealed using any suitable mean, including, for example, welds **17** as shown in **FIG. 4D**.

FIGS. 4E and **5E** illustrate flotation member **20** coupled to membrane **10**. Flotation member **20** includes float **22** and float compartment membrane **24**. In both figures, float compartment membrane **24** is coupled to lower surfaces **11** and **41** of membranes **10** and **40**, respectively. **FIG. 4E** shows that the coupling may be achieved through the use of welds **17**, and **FIG. 5E** shows that the coupling may be achieved through the use of fastener **12**. In both figures, float compartment membrane **24** forms float compartment **27**. This float compartment can be sealed using any suitable mean, including, for example, one or more welds **17** as shown in **FIG. 4E**.

FIGS. 4F and **5F** illustrate flotation member **20** coupled to membrane **10**. Flotation member **20** includes float **22** and float compartment membrane **24**. As shown in both figures, float **22** is positioned between float compartment membrane **24** and membrane **10**. In both figures, float compartment membrane **24** is coupled to upper surfaces **13** (in two locations) and lower surface **41** of membranes **10** and **40**, respectively. **FIG. 4F** shows that the coupling may be achieved through the use of welds **17**, and **FIG. 5F** shows that the coupling may be achieved through the use of fasteners **12**. In both figures, membrane **10** and float compartment membrane **24** form float compartment **27**. This float compartment can be sealed using any suitable mean, including, for example, welds **17** as shown in **FIG. 4F**.

FIGS. 4G and **5G** illustrate flotation member **20** coupled to membranes **10** and **40**. In both figures, flotation member **20** includes float **22** and float compartment membranes **24** and **25**. As shown in both figures, float **22** is positioned between float compartment membranes **24** and **25**. In both figures, float compartment membrane **25** is coupled to lower surfaces **11** and **41** of membranes **10** and **40**, respectively. In both figures, float compartment membrane **24** is coupled to float compartment membrane **25**. **FIG. 4G** shows that the above-described coupling may be achieved through the use of welds **17**, and **FIG. 5G** shows that the above-described coupling may be achieved through the use of fasteners **12**. In both figures, float compartment membranes **24** and **25** form float compartment **27**. This float compartment can be sealed using any suitable mean, including, for example, welds **17** as shown in **FIG. 4G**.

Although **FIGS. 4A-G** and **5A-G** illustrate the use of either fasteners **12** or welds **17** for coupling the present flotation members to the present membranes, it will be understood that fasteners and welds may be intermixed such that welds are used on one side of a given flotation member and fasteners on the other, or both welds and fasteners are used on the same side in an alternating or random fashion.

FIG. 12A illustrates flotation member **20** coupled to membrane **10** with weld **17**, which may be a continuous and elongated and span the length of much of flotation member **20**. Alternatively, multiple spot welds **17** may be used in place of a continuous, elongated weld. As shown in **FIG. 12A**, flotation member **20** includes float **22** and float

compartment membrane **24**. In this embodiment, float **22** is sealed within float compartment membrane **24**. Further, float compartment membrane **24** and, thus, flotation member **20**, is coupled to lower surface **11** of membrane **10**. **FIG. 13** illustrates a perspective view of the configuration depicted in **FIG. 12A**, and includes two pluralities of gas-relief passageways **26**, both pluralities being positioned within membrane **10** and being adjacent to flotation member **20** on alternate sides thereof.

FIG. 12B illustrates flotation member **20** coupled to membrane **10** with at least one flotation member strap **120**. More specifically, **FIG. 12B** illustrates an embodiment in which flotation member **20** is coupled to membrane **10** with at least one flotation member strap **120** that is secured to lower surface **11** of membrane **10** with welds **17**. The present flotation member straps may be made from any of the materials disclosed herein that may be used for the present membranes or the present float compartment membranes. Multiple flotation member straps may be used, depending on the length of flotation member **20** and any other relevant factors. As an alternative to welds **17**, fasteners may be used to secure flotation member strap **120** to membrane **10**. As with all of the present embodiments involving welds **17**, the welds may be spot welds or elongated, continuous welds. As shown in **FIG. 12B**, flotation member **20** includes float **22** and float compartment membrane **24**. In this embodiment, float **22** is sealed within float compartment membrane **24**.

FIG. 12C illustrates flotation member **20** coupled to membrane **10** with at least one flotation member tie **130**. Membrane **10** may be configured, or provided, with tie openings (not shown for simplicity) through which flotation member tie **130** can extend. In addition, multiple flotation member ties may be used, depending on the length of flotation member **20** and any other relevant factors. The ends of flotation member tie **130** may be secured with securing element **132**. The present flotation member ties may be cables, ropes, straps made of any of the materials disclosed herein for use as the present membranes and float compartment membranes, cable ties, etc. Depending on what flotation member tie **130** is made of, securing element **132** may be a knot, a clamping device, a crimped piece of metal, a piece of heat-shrink tubing, or any other device that is suited to securing two ends together.

FIG. 6 illustrates a close-up cross-sectional view of the position of gas-relief passageway **26** (which may be part of a plurality of gas-relief passageways not shown) in relation to other portions of membrane **10**. **FIG. 6** illustrates that by coupling membrane **10** to float compartment membrane **24** in the manner shown, gas pocket **29** is created when the illustrated embodiment of the present covers and covering systems is used. Gas may collect within gas pocket **29**. Because gas-relief passageway **26** is positioned within membrane **10** at a location that is above at least a portion **19** of membrane **10** when the embodiment shown is in use, any gas from the covered body (note liquid surface **18**) that collects above liquid surface **18** and within gas pocket **29** is allowed to flow unobstructed through gas-relief passageway **26**.

FIG. 7 shows a top view of one embodiment of the present covers and covering systems. In this embodiment, four membranes **10** are shown, each of which is attached to either a T-shaped membrane **60** or a T-shaped membrane **40**. Also shown are elongated weights **90** and **90'** (pronounced "ninety prime") positioned on the upper surfaces (un-numbered for simplicity) of each of the membranes shown. Elongated weights **90'** are positioned on the upper surfaces of the membranes at angle **c** to elongated weights **90**, at angle **b** to flotation members **50**, and at angle **a** to flotation members **20**. The present elongated weights may be positioned at any angle with respect to other elongated weights and/or flotation members that is suited for a given application. The float compartment membranes, the gas-relief openings, and the fasteners shown in **FIG. 7** are not numbered for simplicity and ease-of-viewing. The same is true for the details of the anchor system **70** coupled to the outside edges of the membranes.

FIGS. 8A and **B** and **FIGS. 9A** and **B** illustrate that the present membranes may be provided with service openings at any suitable location within the membrane. This facilitates the ability of operators or users of the present covers and covering systems to place the cover or covering system over equipment that already exists. It also allows workers to introduce new equipment to the liquid-retaining structure through the service opening. The service openings discussed herein may be positioned anywhere within the present membranes that is suited to the application. For example, placing one of the present service openings near one of the present flotation members may facilitate the ability of workers to walk on and work from the flotation member when introducing new

equipment through the service opening or servicing existing equipment positioned within the service opening.

FIG. 8A illustrates a partial view of one embodiment of the present covers and covering systems that includes membrane **10** and service opening **94** (which may be characterized as a first service opening, a second service opening, etc., depending upon the context, as is true of all of the present service openings) positioned within membrane **10**. Service opening **94** is defined by service opening edge **90** that is, although not shown, spaced apart from any flotation members, and pluralities of openings that may also characterize the illustrated embodiment. A flotation member in the form of floats **92** is coupled to membrane **10** (specifically, to the lower surface of membrane **10** as evidenced by the dashed lines outlining floats **92**) so as to elevate service opening edge **90** above the surface of the body containing some liquid (not shown) over which membrane **10** is positioned. That is, floats **92** are coupled to the lower surface of membrane **10** so as to elevate service opening edge **90** above the surface of the body containing some liquid when the embodiment of the present covers and covering systems is used. Service opening membrane **96** (which may be characterized as a first service opening membrane, a second service opening membrane, etc., depending upon the context, as is true of all of the present service opening membranes) is coupled to service opening edge **90**. In one embodiment, service opening membrane **96** may include multiple pieces of material affixed along different portions of service opening edge **90** and to each other. In another embodiment, service opening membrane **96** may include a single piece of material. Floats **92** may be configured in the same way. That is, one or more floats **92** may be used to form the flotation member that is coupled to the lower surface of membrane **10** so as to elevate service opening edge **90** above the surface of the body containing some liquid when the particular cover or covering system is in use. Alternatively, a single float **92** (which would make up one of the present flotation members) may be used, as shown in **FIG. 8B**.

Using a service opening membrane in the way depicted in **FIGS. 8A** and **B** will prevent liquid from the body, or liquid-retaining structure, over which the particular cover or covering system is placed from finding its way to the upper surface(s) of the present membranes. This follows because the present service opening membranes (which

may be formed from any of the same materials as the present membranes, and which may be coupled to the present service opening edges in any suitable fashion, such as using welds or any other suitable means discussed herein) can be dimensioned so as to dip into the liquid being covered. Adding to this the fact that a flotation member (such as the one shown in **FIG. 8A** in the form of floats **92**) may be used to elevate any of the present service opening edges above the body it covers, the likelihood of liquid from the body getting onto the upper surfaces of the present membranes is minimized.

FIG. 9A shows that multiple service opening weights **98** (which, individually, may be characterized as a first service opening weight, a second service opening weight, etc., depending upon the context, as is true of all of the present service opening weights) may be coupled to service opening membrane **96** (the weights are used to sink the service opening membrane) and spaced apart from service opening edge **90**. Such weights may be useful in minimizing the effects of wind on the present covers and covering systems. As shown in **FIG. 9B**, a single float **92** (which would make up one of the present flotation members) may be used in placed of multiple floats **92** shown in **FIG. 9A**.

The present methods, in addition to including venting methods, include methods for creating a service opening in a liquid-retaining structure cover or covering system. The benefits that can be realized from providing the present service openings in the present covers and covering systems may also be realized by creating, or providing, the present service openings in existing liquid-retaining structure covers. Thus, a method of accomplishing this includes cutting the service opening in the cover, the service opening being defined by a service opening edge. The method, in one embodiment, also includes reinforcing the service opening edge. The reinforcing may include attaching a reinforcing material to the service opening edge. The reinforcing material may be made from any suitable material, including any of those described herein for use as the present membranes. The attaching may include welding or applying an adhesive. In one embodiment, the method can include coupling one of the present flotation members to the lower surface of the cover around the service opening edge. In another embodiment, the method includes coupling a service opening membrane to the service opening edge, either before or after reinforcing the service opening edge, or in lieu of reinforcing the service opening edge. In another embodiment, one or more service opening weights may

be coupled to a service opening membrane that is coupled to the service opening edge. The service opening edge may be configured to be of any suitable size, including any dimension within the range of 1 square foot to 500 square feet, depending upon the application. For example, if a large piece of equipment needed to be installed in the liquid-retaining structure beneath an existing cover, but it is impractical for whatever reason to remove or lift the cover in order to effect the installation, one of the present service openings could be provided in the existing cover using this method to permit that installation. The service opening could be sized to fit the piece of equipment in need of installation.

One of the advantages of present covers and covering systems is their cost-effectiveness. The present floats may have widths that are substantially less that the widths of the present membranes. This can reduce costs over systems such as those shown in U.S. Patent Nos. 5,400,549 and 5,562,759, which include modules with insulative enclosures that span nearly the entire width of the enclosing membranes. **FIG. 10** shows membrane **10** as having width **WM**. **FIG. 10** also shows float **22** as having width **WF**. Width **WF** may be any percentage of width **WM** that is suited for the application. For example, width **WF** may be 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, or 50 percent of width **WM**. Similarly, width **WF** may be not more 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, or 50 percent of width **WM**. Any of the present float and membrane combinations described herein may have these relationships in terms of widths.

FIG. 11 shows gas-relief openings **100** as an alternative to gas-relief passageways **26**. **FIG. 11** illustrates membrane **10** coupled to flotation member **20**, which includes float **22** and float compartment membrane **24**. Float compartment membrane **24** is coupled to lower surface **11** of membrane **10** using welds **17**. In coupling float compartment membrane to membrane **10**, it will be understood by those of skill in the art that welds **17** can extend continuously along one or both of the edges of float compartment membrane **24** as evidenced by the dashed lines extending between two of the edges of membrane **10**. Alternatively, welds at intermittent locations may be used.

Gas-relief passageways **26** are positioned within membrane **10** and float compartment membrane **24** on the opposite side of flotation member **20** from fasteners **12**. As shown in **FIG. 11**, width **WF** of float **22** is not more than 25 percent of width **WM** of membrane **10**. Membrane **40** is coupled to upper surface **13** of membrane **10** using fasteners **12** positioned at intermittent, or spaced apart, locations. As a result, gas-relief openings **100** are defined between membrane **10** and membrane **40**. Gas that collects in gas pocket **29** may pass through gas-relief openings **100**. It is also possible for gas-relief openings to be created through the use of intermittent welds instead of intermittent fasteners.

FIG. 14 shows an embodiment of the present covers and covering systems in which two flotation members are coupled through the use of flotation member tie **130**. In the embodiment shown in **FIG. 14**, flotation member **20**, which includes float **22** and float compartment membrane **24**, is coupled to membrane **10** with at least one flotation member strap **120**. Two pluralities of gas-relief passageways **26** positioned within membrane **10** and both being adjacent to flotation member **20** on alternate sides thereof. The flotation member strap shown is coupled to membrane **10** with welds **17**. **FIG. 14** also shows that another configuration, such as the one just described (but which is not completely illustrated), can be coupled to the configuration depicted with at least flotation member tie **130**. Specifically, flotation member tie **130** is shown coupling flotation member **20** to flotation member **20'**. As shown, flotation member tie **130** is coupled to float **22** at float tie link **140**, which may take the form of a ring through which flotation member tie **130** can be threaded, and the like. The same float tie link, although not shown, may be provided on float **22'**. Flotation member **20'** is shown as including float **22'** and float compartment membrane **24'**. Although not shown, a membrane having two pluralities of gas-relief passageways can be coupled to flotation member **20'** in the same fashion that membrane **10** is coupled to flotation member **20** in **FIG. 14.** Using flotation member ties in the fashion shown in **FIG. 14** allows one to connect the ends of the present flotation members together to that the present covers and covering systems can be better adapted to a given fluid-retaining structure.

It will be understood by those of skill in the art that, although not depicted, it is possible to couple multiple flotation members to each other in end-to-end fashion as shown in **FIG. 14** and couple those coupled flotation members to a single membrane,

such as membrane **10** in **FIG. 14**. In such an embodiment, the flotation members may be connected to membrane **10** using any of the mechanisms disclosed herein, such as via welds, flotation member straps or ties, or fasteners. Furthermore, combinations of these securing mechanisms may be used. In such an embodiment, one of the present covers or covering systems would include a second flotation member coupled to the first membrane, wherein the second flotation member includes a second float and a second float compartment membrane, and wherein the second float compartment membrane is coupled to the first membrane. In this embodiment, one of the present covers or covering systems would also include a flotation member link coupling the first flotation member to the second flotation member.

The steps that it takes to achieve the present covers and covering systems, and to place those covers and covering systems over bodies containing at least come liquid, make up different embodiments of the present methods, which include venting methods, and more specifically, methods of venting gas from a body containing some liquid. In addition, the present methods may also, depending upon the application, include positioning any of the present covers and covering systems over a body containing some liquid to allow gas from the body to vent to atmosphere around the outer (or outside) edge of at least one of the membranes used to form the cover or covering system so positioned. This may be useful in covering small-sided basins or tanks, for example.

Advantageously, the present methods, covers, and covering systems may be utilized in any environment, and built to any size suited to the application. The membrane or membranes used may range in thickness from a few thousandths of one inch to several hundred thousandths of one inch thick. The float compartment membrane or membranes used may range in thickness from a few thousandths of one inch to several hundred thousandths of one inch thick. The materials used for the membranes, float compartment membranes and the like may float when placed on a liquid, such as water, that is more dense than the material. In addition, the present covers and covering systems may be built to be large enough that it is possible for people to safely walk across them.

All of the present covers, covering systems, and methods can be made and executed without undue experimentation in light of this disclosure. Additionally, while

this invention have been described in terms of specific embodiments, it will be apparent to those of skill in the art that variations to the disclosed embodiments not specifically listed may be applied to achieve the present methods, covers, and covering systems without departing from the scope of the invention.